The exact nature of possible outcomes cannot be defined. One possibility is that the drift toward dominance by the corporate elite will continue and even be accelerated in adversity by the politicians' desire to "restore business confidence." Then, government programs and policies, basically subservient to the dictates of the potent minority, would put greater emphasis on progress for business, and the supporting political party greater emphasis on law and order. As an alternative, the combination of economic instability and public frustration might at some point produce a new political party and a government basically detached from the corporate sector as now constituted. In that case a basic reformation of the corporation laws would probably be undertaken to make top corporate personnel accountable and removable as well as to make corporations more explicitly public institutions with a share of responsibility for the public interest in both good times and bad. In either case, the change would be presented as a response to popular demands, and the semblance of democratic forms would be preserved, however much they might be subordinated to authoritarian leadership. In either case, also, the mixed economy would be dead.

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V Lewis Bassie
University of Illinois
December, 1979

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Faculty Working Papers

TIME SERIES ANALYSIS IN ACCOUNTING: A SURVEY

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  of Accountancy
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#639

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#689

Summary

     In the last few years there has been considerable interest in the
accounting literature in time series methods. This paper briefly surveys
those areas of accounting in which time series analysis has proved useful
and discusses the analytical procedures that have been employed. In addi-
tion, the relationship between quarterly and annual earnings is theoretically
derived.

1. INTRODUCTION

The objective of this paper is to introduce time series analysts to an area of application which has recently grown fairly dramatically in importance. In the last few years many members of the accounting profession have become interested in time series methodology and have recognized the potential for its application over a range of important practical questions. Except in those areas which infringe on the Finance literature, the analysis of time series of interest to accountants is in its infancy. Certain areas of application have been identified and relatively straightforward methodology has been applied. It seems reasonable to expect, in the next few years, that further developments will be made both in the range of problems considered and the sophistication of the techniques employed.

In the next section we outline a number of areas in accounting research where time series methods have been found useful. Section 3 of the paper discusses methodological issues and describes the procedures which have been employed in the analysis of accounting time series. In the main, the series available have been relatively short and interest has focussed primarily on forecasting, so that most attention has centered on ARIMA model building using the methods of Box and Jenkins (1970).

In what follows the references quoted are intended for illustrative purposes and are by no means exhaustive.

2. AREAS OF APPLICATION

It is often the case that more than one accounting measure of a particular quantity is available and there is debate as to which should

be reported. One possible criterion is "predictability," that is the alternative measures can be compared on the basis of how well they predict some variable of interest to the decision maker. This view is expressed, for example, by Beaver et al (1968) and by the Financial Accounting Standards Board (1978a,b).

That predictability viewed in this way provides one reasonable comparison of alternative reporting procedures seems unarguable. More debatable is the notion that different accounting measures might be compared in terms of how well they are predicted by their own past history. Using simple linear extrapolation, Simmons and Gray (1969) compared in this way replacement cost income with traditional historical cost income (For a summary of the issues involved in replacement cost reporting see Samuelson 1980).

A similar type of reasoning is inherent in the work of Dopuch and Watts (1972), who are concerned with assessing the effects of a change in reporting procedure. Asserting that "the significance of an accounting change may be assessed in terms of its effect on the parameters of the time series model which best describes a firm's income generating process," they based their conclusions on changes in the parameters of fitted ARIMA models. These models were fitted to data from before the change, data from after the change and to the pooled data set. Dopuch and Watts reasoned that a change in accounting method which produced no change in the model parameters might not affect the decisions made on the basis of the data. It might be useful to apply the technique of intervention analysis (Box and Tiao 1975) in this area.

Leaving aside the question of precisely which accounting series are reported, forecasts of future values of these series, particularly of corporate earnings, have attracted considerable attention. In a sense interest in predicted earnings is motivated by the fact, Ball and Brown (1968), that, if future earnings were known to an individual, he could obtain a higher expected rate of return on investment than that predicted by the Capital Asset Pricing Model of Sharpe (1964), Lintner (1965) and Mossin (1966). This excess return is often called an "abnormal return" since it measures the private value of knowing in advance the earnings figure. The existence of this private value has, in the absence of certainty about the future earnings stream, apparently provided an incentive for forecasting future earnings. Certainly financial analysts are known to be heavy users of such forecasts (see, for example, Norby 1973).

Since earnings forecasts are assumed to be of positive value to the investor, and given a philosophy that, in fairness, all investors should have equal access to relevant information, the U.S. Securities and Exchange Commission has repeatedly urged companies to publish their earnings forecasts, and have even considered making such reporting a requirement for listed companies. (See Prakash and Rappaport (1974) and Wall Street Journal (1978)). A primary function of accounting is to audit published reports, so that in anticipation of developments of this kind, there is an incentive for accountants to acquire knowledge about forecasting methods in general, and the time series properties of corporate earnings in particular.

Quite apart from the value of forecasts in the investment decision making process, there are several other reasons for practicing and research accountants to be interested in time series forecasting models. For example, corporate management has a certain amount of discretion in the selection of accounting methods for such things as inventory valuation and fixed asset accounting. It is interesting to ask whether or not this discretion is used to "manipulate" income in such a way that management is viewed in the most favorable possible light. It is hypothesized, for example, that managers would prefer to present an income series which is as "smooth" as possible. An empirical procedure to assess whether or not managers take advantage of their allowed discretion to smooth income streams has been based on the determination of a "target income," derived as the forecast from some time series model. This target value is then regarded as the most desirable reported figure from management's point of view. Any changes that have been made in accounting methods are then examined to determine whether they brought reported income closer to the target value than had the changes not been made. Discussion of this issue and methodology is given in Barnea et al (1976) and Smith (1976).

A further question of interest is concerned with the information content of reported accounting figures. To examine this issue, models have been built to generate forecasts, or "equilibrium values," for corporate earnings. The forecast is then subtracted from the observed earnings figure, giving "unexpected earnings." It is then held that, if reported earnings contain any information content, unexpected earnings should be associated with abnormal return, as defined, above. This

methodology was introduced by Ball and Brown (1968) and is applied, for example, by Foster (1977), Brown and Kennelly (1972) and Joy et al (1977).

An important phase of an auditor's work is in determining whether or not the account balances are correct. This determination can sometimes be helped by forecasting the account balances and then giving special attention to those balances which differ substantially from their forecasts. Such a procedure is discussed by Stringer (1975). Kinney (1978) has employed univariate ARIMA models for this purpose, while Albrecht and McKeown (1977) propose the use of single input transfer function-noise models.

A final point of concern to accountants is whether or not stock market prices fully reflect all publicly available information. Under certain conditions (see, for example Fama 1965, 1970) it can be shown that if this is the case stock returns will be white noise, where the return R_t is defined as

$$R_t = \frac{(P_t - P_{t-1}) + D_t}{P_{t-1}}$$

where P_t is price and D_t dividend. Thus there has been considerable interest in the time series properties of stock prices and returns. These have been studied both through the estimated correlogram (Lookabill and McKeown 1976) and through spectral analysis (Praetz 1979 and the references therein). This literature, then, is concerned with testing the hypothesis that the underlying spectrum is flat.

3. METHODOLOGY

In this section we explore some of the methodological issues which have arisen in the analysis of accounting data. Attention is focussed on the construction of models for the analysis and prediction of corporate earnings, since this has been the area of most intense research activity. The procedures discussed here have also been applied, to a lesser extent, in several of the areas discussed in the previous section.

There has been longstanding professional interest in corporate earnings forecasts. Many early studies, such as Reilly et al (1972), Little (1962), Little and Rayner (1966), Green (1964), Green and Segal (1967), Copeland and Marioni (1972), Beaver (1970), Cragg and Malkiel (1968) and Coates (1972) used such "rule of thumb" predictors as "last available value" or "average of previous values." A detailed discussion of these procedures is given in Abdel-khalik and Thompson (1977-8). Ball and Watts (1972) derived forecasts $\overline{X}_t$ for X_{t+h} (h = 1, 2, ...) from the simple exponential smoothing model

$$\overline{X}_t = \alpha X_t + (1-\alpha)\overline{X}_{t-1} \qquad , 0 < \alpha < 1$$

The methodology of Box and Jenkins (1970) was introduced in the accounting literature by Dopuch and Watts (1972). Since that time considerable effort has been spent on the construction and use of ARIMA models of corporate earnings for both quarterly and annual data. Various models from the ARIMA class have been built for individual series, model selection being based in the usual way on sample autocorrelations and partial autocorrelations of the series and its appropriate differences. However, accountants have also looked for a specific model form

from the general class which might be used to model all earnings series, thus circumventing the need for individual model identification. There is an obvious advantage in having such all-purpose models when, as is often the case, a large number of series are to be analyzed. Moreover, since time series of essentially similar quantities are being considered it may well be that, on the average, more is lost through selecting individual models which are inappropriate than through forcing the same model type on every series. Jenkins (1979) also fits common model structures for sales series.

Quarterly series of corporate earnings are seasonal and attempts to model them have been based on the multiplicative ARIMA class, written in the notation of Box and Jenkins (1970),

$$\phi(b)\Phi(B^s)(1-B)^d(1-B^s)^D X_t = \theta(B)\Theta(B^s)a_t \qquad (3.1)$$

The usual Box-Jenkins model building framework involving model selection, estimation and checking has been employed in the analysis of individual earnings series, but accountants have also searched for individual models from the general class which might well represent an ensemble of series. Three such "premier" models have been reported and investigated in the accounting literature:

(i) Foster (1977) considered the $(1, 0, 0) \times (0, 1, 0)_4$ model

$$(1-\phi B)(1-B^4)X_t = a_t \qquad (3.2)$$

Containing, as it does, just a single autoregressive parameter, its computational attractions are obvious. However, Foster and others concluded that it failed to

incorporate fully all systematic autocorrelation be-
havior in the series.

(ii) Griffin (1977) and Watts (1975) proposed the (0, 1, 1) x
(0, 1, 1)$_4$ model

$$(1-B)(1-B^4)X_t = (1-\theta B)(1-\Theta B^4)a_t \qquad (3.3)$$

which, of course, has been widely used in other areas.

(iii) Finally, Brown and Rozeff (1979) suggested the (1, 0, 0) x
(0, 1, 1)$_4$ model

$$(1-\phi B)(1-B^4)X_t = (1-\Theta B^4)a_t \qquad (3.4)$$

The Foster model (3.2) is, of course, the special case of
(3.4) with $\theta = 0$.

The time series with which accountants have worked are typically
fairly short, with the number of observations generally between 50 and
100. One difficulty with such series for models, such as (3.3) and
(3.4), which contain seasonal moving average terms is that many of the
readily available least squares estimation routines can and often do
produce estimates outside the invertibility region. Although such esti-
mates are devoid of any worthwhile interpretation they have sometimes
been reported, without comment, in the accounting literature. One has,
of course, to be skeptical of the conclusions drawn from such analyses.

Attempts have been made to compare the forecasting performances of
the three premier models with one another and with a full Box-Jenkins
analysis in which, for each series, the form of the model is dictated
by the data. Collins and Hopwood (1980) found, on average, the Foster

model produced poorer forecasts than the other two premier models. They
could find no advantage, in terms of forecasting accuracy, in using a full
Box-Jenkins analysis rather than one or other of the more successful pre-
mier models.

One use of univariate time series models is in providing a yardstick
against which forecasts obtained from other sources can be judged. Cor-
porate earnings forecasts are regularly produced by financial analysts
who study intensively the various factors affecting a company's perfor-
mance. These forecasts are typically judgmental in nature and results of
Brown and Rozeff (1978) indicate that, on the average, they are appre-
ciably more accurate than predictions derived from univariate time series
models.

Graphical inspection of individual earnings series often suggests
greater variability in the data at higher earnings levels. In these
circumstances it is natural to consider fitting the ARIMA model (3.1),
not to X_t, but to the power transformation $X_t^{(\lambda)}$ of Box and Cox (1964),
where

$$X_t^{(\lambda)} = \begin{array}{ll} (X_t^\lambda - 1)/\lambda & (\lambda \neq 0) \\ \log X_t & (\lambda = 0) \end{array}$$

Hopwood et al (1980) fitted models augmented in this way to a random
sample of 50 series of corporate earnings per share. For each series
the three premier models (3.2)-(3.4) were used and also a model was
selected from the general class (3.1) using a full Box-Jenkins analysis.
The models were estimated by full maximum likelihood and the evidence
in the data in favor of a power transformation can be gauged from the

fact that for about half of the series 95% confidence intervals for λ, calculated from the estimated information matrix, did not contain the value λ = 1. Moreover, for these series, use of the transformation led to a marked improvement in post-sample forecast accuracy. Overall it was found that the Griffin-Watts model outperformed the two other premier models and differed little on the average from a full Box-Jenkins analysis. Although use of the power transformation produced some improvement in forecast accuracy, the univariate time series models were still noticeably outperformed by financial analysts' forecasts.

The question as to whether the process generating earnings is stationary is interesting. Certainly many accountants are skeptical of the stationarity assumption, but empirical evidence is sparse and inconclusive due to the fact that long series are not available. Lorek and McKeown (1978) found that, at least up to sample size 50, increasing the number of observations on which the model was built led to improved forecast accuracy. On the other hand, McKeown and Lorek (1978) found that, as sample size is increased, repeating the whole Box-Jenkins identification, estimation and checking cycle led to better forecasts then resulted from merely re-estimating a previously identified structure. These results could, of course, be indicative of the advantage of having more observations for model specification rather than inherent non-stationarity.

Recently transfer function-noise models relating an individual earnings series to an index of all earnings have been introduced. Using the methodology of Box and Jenkins (1970), Hopwood and McKeown (1980) found the model

$$(Y_t - Y_{t-4}) = \omega_0(X_t - X_{t-4}) + \frac{(1-\theta B^4)}{(1-\phi B)}\, a_t \qquad (3.5)$$

to be widely applicable. In (3.5) Y_t denotes individual corporate earnings per share and X_t a market index of all corporate earnings.

For series of annual earnings there seems to be near unanimity that the appropriate model is the random walk. For example, Albrecht et al (1977) and Watts and Leftwich (1977) found that a full Box-Jenkins analysis of individual series did not, on the average, produce more accurate forecasts than a simple random walk. One reason for this may be that the series examined were very short. Further support for the random walk model is contained in the papers by Ball and Watts (1972), Beaver (1970), Brealey (1969), Little and Rayner (1966), Lookabill (1976) and Salamon and Smith (1977).

Unfortunately the time series models which have been found to be most appropriate for representing quarterly earnings series do not imply a random walk model for the annual aggregates. Let X_t denote the quarterly series and Y_t the corresponding series of non-overlapping annual totals. For notational simplicity, in writing annual models the subscript t will refer to periods of one year, the operator B shifts the series back one year and ε_t is the corresponding white noise. For any model in the ARIMA class (3.1) a model for the annual aggregates can be deduced from general results given in Brewer (1973). However, for the three premier models the required models can be obtained directly.

For the Foster model, it follows from multiplying through (3.2) by $(1+\phi B+\phi^2 B^2+\phi^3 B^3)(1+B+B^2+B^3)$ that the model for non-overlapping annual aggregates is ARIMA (1, 1, 1), of the form,

$$(1-\phi^4 B)(1-B)Y_t = (1-\theta^* B)\epsilon_t$$

where θ^* is a function of ϕ which can be deduced as follows: let

$$U_t = (1-\theta^* B)\epsilon_t$$

$$V_t = (1+\phi B+\phi^2 B^2+\phi^3 B^3)(1+B+B^2+B^3)a_t.$$

Then

$$\text{Corr. } (U_t, U_{t-1}) = \text{Corr. } (V_t, V_{t-4})$$

and θ^* can be derived from this correlation.

Similarly, for the Griffin/Watts model, multiplying (3.3) by $(1+B+B^2+B^3)^2$, it follows that the annual totals obey an ARIMA (0, 2, 2) process

$$(1-B)^2 Y_t = (1-\theta_1^* B-\theta_2^* B^2)\epsilon_t$$

where θ_1^* and θ_2^* are functions of θ and Θ found from

$$U_t = (1-\theta_1^* B-\theta_2^* B^2)\epsilon_t$$

$$V_t = (1+B+B^2+B^3)^2(1-\theta B)(1-\Theta B^4)a_t$$

with

$$\text{Corr. } (U_t, U_{t-j}) = \text{Corr. } (V_t, V_{t-4j}) \quad (j=1,2)$$

and θ_1^*, θ_2^* following from these correlations.

Finally, for the Brown and Rozeff model, multiplying through (3.4) by $(1+\phi B+\phi^2 B^2+\phi^3 B^3)(1+B+B^2+B^3)$ it follows that the annual totals obey the ARIMA (1, 1, 2) model

$$(1-\phi^4)(1-B)Y_t = (1-\theta_1{}^*B-\theta_2{}^*B^2)\epsilon_t$$

where $\theta_1{}^*$ and $\theta_2{}^*$ can be found as functions of ϕ and θ from

$$U_t = (1-\theta_1{}^*B-\theta_2{}^*B^2)\epsilon_t$$

$$V_t = (1+\phi B+\phi^2 B^2+\phi^3 B^3)(1+B+B^2+B^3)(1-\theta B^4)a_t$$

with

$$\text{Corr. } (U_t,U_{t-j}) = \text{Corr. } (V_t,V_{t-4j}) \quad (j=1,2)$$

These results are of more than academic interest. There is obviously a cost involved when corporations are required to report earnings on a quarterly rather than annual basis. The benefits obtained from the additional reports, in terms of improved accuracy in the prediction of annual totals, can now be derived in a straightforward manner.

Recently Chant (1980) has found a simple "leading indicator" model which predicts annual corporate earnings more accurately on the average than the simple random walk. Chant's predictor $\hat{Y}_{t+1}$ of earnings in year t+1 is

$$\hat{Y}_{t+1} = Y_t(M_t/M_{t-1})$$

where M_t is the money supply. He also considered predictors of this form using other leading indicators. The development of more sophisticated models of this kind is likely to be inhibited by the paucity of data.

4. SUMMARY

In this paper we have briefly outlined the motivations for the increased interest in time series methods that has recently developed in the accounting literature. Attention has been most heavily concentrated on the development of forecasting models using the methodology outlined by Box and Jenkins (1970). It should be clear from our survey that there remain many interesting issues which so far have not been satisfactorily resolved. As one example, the exploitation of multivariate methods is as yet in its infancy in this area.

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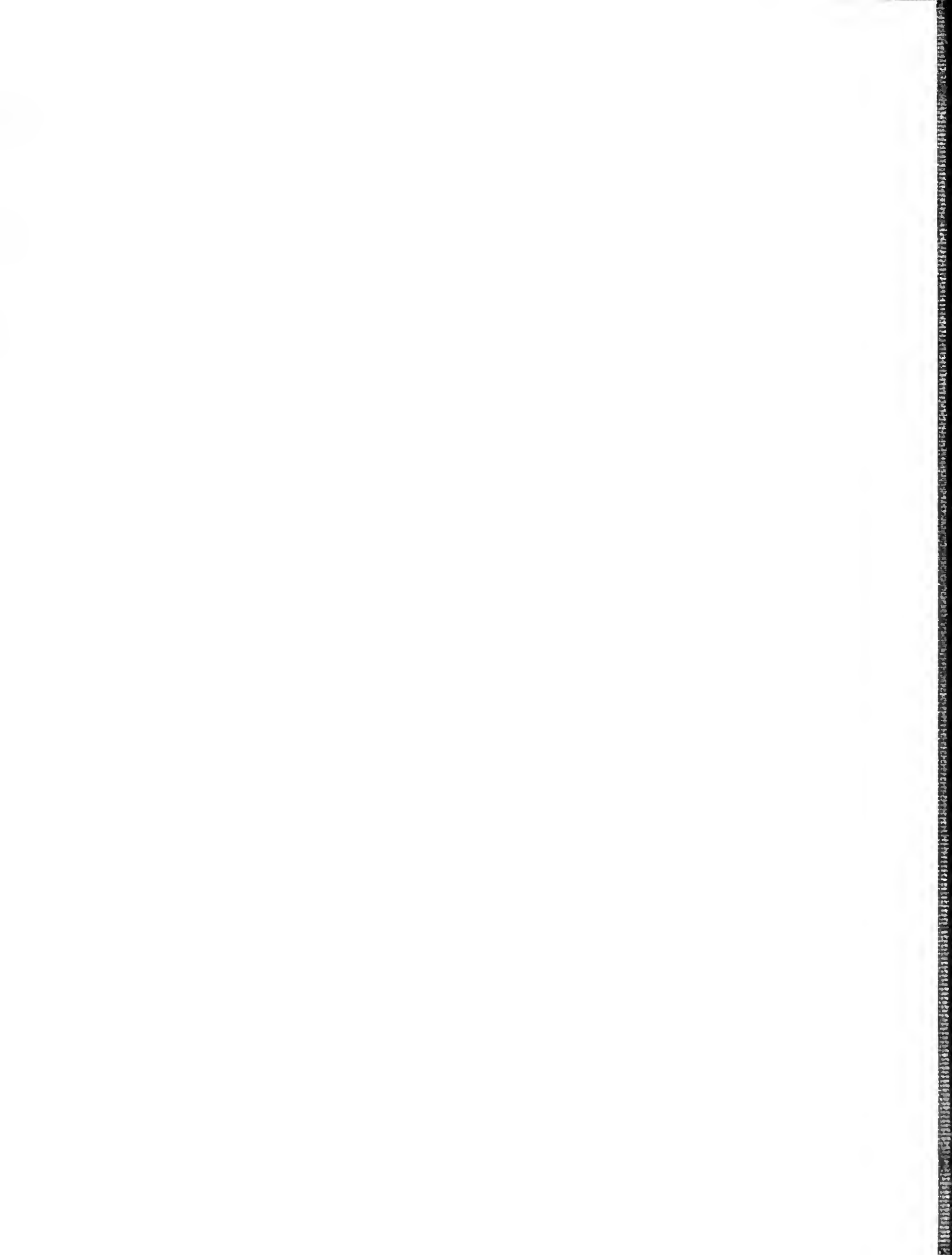
Faculty Working Papers

AN EVALUATION OF TRANSFER-FUNCTION AND UNI-
VARIATE TIME-SERIES EARNINGS EXPECTATION MODELS

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